BIRD NESTING AND DROPPINGS IN HIGH-RISE BUILDINGS: A LITERATURE REVIEW

Dissanayaka, D.M.K.S., Rajini, P.A.D. and Samarakoon, W.K.U.R.M.K.P.K.*
University of Moratuwa, Sri Lanka
*Corresponding Author: samarakoonk@uom.lk

Abstract. Bird nesting and droppings create substantial barriers to the operations and maintenance of high-rise buildings in urban areas, consequently creating numerous issues for buildings and their stakeholders. Therefore, it is crucial to properly investigate this significant problem and provide robust solutions. As an initial step, a comprehensive literature review on the research domain was conducted to explore the concerns of bird nesting and droppings in high-rise buildings, employing content analysis as the analysis method. Findings revealed that numerous factors affect bird nesting and droppings, which can cause impacts on building elements, health and safety of building stakeholders, aesthetic aspects of the building, and financial status of the business carried out in the building. According to the findings, the strategies that are currently practised to manage these issues include integrated pest management, habitat modification, physical and bio-acoustic deterrents, chemical repellents and technological solutions. The findings of this comprehensive literature review establish a strong foundation to enhance the field of facilities management in urban high-rise structures by providing essential knowledge on this long-standing issue. In addition, this study creates a basis for future research to identify more effective prevention methods and improved facility planning, design, and management practices.

Keywords. Bird Nesting; Bird Droppings; High-Rise Urban Structures; Bird-Related Issues

1. Introduction

The rapid growth of cities through urbanisation has sparked an extensive trend of high-rise construction throughout urban areas. These built structures provide essential housing and commercial spaces, especially in densely populated metropolitan regions. The increasing number of high-rise developments has led to unintended consequences, including greater interactions between birds and buildings (Gelder, 2003). The adaptation of urban habitats by birds such as pigeons, crows, and house sparrows has made high-rise buildings suitable for perching, roosting, and nesting (Fitzwater, 1988). These nesting habits and bird droppings in high-rise buildings create numerous operational challenges and issues for urban facilities and residents. In particular, they lead to unanticipated building maintenance problems and negatively impact both visual appeal and public health conditions (Janus & Lesinski, 2018).

Despite the growing challenges posed by bird nesting and droppings, limited research has been conducted on this issue in the context of high-rise buildings. Specifically, there is a lack of scientific evidence that comprehensively reviews the extent of the problem and its consequences. To address this research gap, this study aims to critically review the available literature on the impact of bird nesting and droppings, highlight several bird-attracting factors, and evaluate existing control strategies. Furthermore, the objectives are to identify key factors that attract birds to high-rise buildings, analyse the main impacts of bird nesting and droppings on high-rise structures, and investigate current bird management strategies. The uniqueness of this work is that it provides a holistic review of a significant real-world problem that high-rise buildings face and its state-of-the-art up to date. With the limitation of focusing entirely on high-rise building settings in

https://doi.org/10.31705/ICFMF2025.7

urban areas, this paper is organised to provide background on the problem, outline the methodology, present the literature findings, and conclude with key insights.

2. Methodology

To achieve the aim, a qualitative method was adopted for conducting this literature review. Papers related to bird droppings and nesting in building stock were identified through searches performed in academic databases such as ScienceDirect and Scopus. Only 21 relevant studies published over the past forty years (from 1985 to 2025) were recognised. Furthermore, a manual content analysis was used to synthesize the selected literature, as it was considered ideal for this paper's context due to its ability to provide rich qualitative insights from a limited and manageable number of papers, while also enhancing the depth, nuance, and flexibility of the review (Torelli et al., 2020)

The design of the review was structured into four main sections to ensure a comprehensive and coherent analysis. First, an overview of the issue of bird nesting and droppings in high-rise buildings was presented in order to establish the context and highlight the significance of the problem. Second, the review examined the key factors contributing to issue's occurrence and persistence, based on insights drawn from the selected literature. Third, a detailed synthesis of the identified impacts was conducted, with particular attention given to their implications within the facilities management context. Finally, the review explored various strategies currently used to mitigate and eliminate bird-related challenges in high-rise building environments.

3. Literature Findings

3.1. INTRODUCTION TO BIRD NESTING AND DROPPINGS IN HIGH-RISE BUILDINGS

Various bird species, such as pigeons, house sparrows, and crows, often choose high-rise buildings in cities as their preferred nesting locations. These structures offer secure roosting areas, protection from predators, and direct access to food resources, making them highly attractive for both roosting and nesting (Kodmany, 2018). As Spennemann & Watson (2018) explain, urban areas provide stable and reliable conditions for birds to nest, leading to large bird populations due to the city's resilience to seasonal changes and limited accessibility for predators. Moreover, bird nests and droppings found in high-rise buildings cause several serious problems, affecting both the structure and appearance of buildings, while also generating financial burdens and health risks (Clark et al., 2020). Consequently, this contributes to the deterioration of structural elements, reduces the building's lifespan, lowers occupant satisfaction with the built environment, and significantly increases costs for maintenance management. Therefore, high-rise environments essentially require effective management strategies due to the existing issues caused by bird populations. Therefore, high-rise environments require effective management strategies to address the challenges posed by bird populations. Although stakeholders involved in the operational phase, such as facilities management staff, building owners, and occupants experience the impact of bird nesting and droppings, it is not sufficient to implement control measures only during the operation and maintenance stages. These concerns should also be

addressed during the planning and design phases of buildings (Janus & Lesiński, 2018).

3.2 FACTORS AFFECTING BIRD NESTING AND DROPPINGS IN HIGH-RISE BUILDINGS

As per the literature findings, various elements that affect bird nesting and droppings in high-rise buildings comprise building architecture, environmental elements, food availability, human actions, and the absence of predators. Figure 1 depicts the main factors that affectg bird nesting and droppings in high-rise buildings, and those factors are collected from several literature. The understanding of these factors serves as a necessity for creating successful management approaches to minimise bird-related problems in cities (Gelder, 2003).

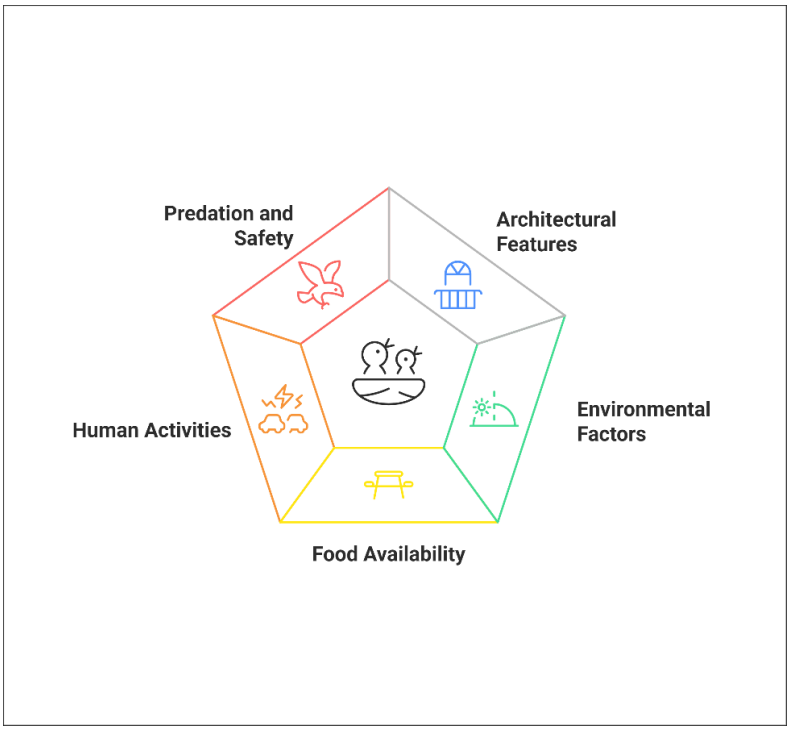


Figure 1: Factors affecting bird attraction

3.2.1 Architectural Features

High-rise building structures together with their architectural elements, create ideal conditions for bird nesting and perching possibilities. Ledges along with balconies, rooftop structures and ventilation openings resemble natural rock formations which attract birds to roost (Spennemann & Watson, 2018). The locations preferred by birds serve as protective shelter from adverse weather conditions and human disturbances (Balasubramaniam et al., 2021). Buildings with rough-textured surfaces enable birds to maintain a better grip, which enhances their chances of establishing nests (Sun et al., 2020). Modern glass facades prevent bird perching, yet they produce accumulated droppings, which impact building appearances (Clark et al., 2020). The nesting behaviour of birds becomes possible through gaps or cracks, which appear in poorly maintained structures (Janus & Lesinski, 2018).

3.2.2 Environmental Factors

Climate conditions together with wind patterns and artificial lighting sources, affect how birds choose their nesting areas (Lowry et al., 2013).The tropical climate of Sri Lanka sustains consistent bird activity across all seasons because of steady temperatures and plentiful food resources, according to Spennemann and Watson (2018). Birds choose their nesting locations based on weather protection, whereby recessed balconies and shaded rooftops serve as suitable shelters (Clark et al., 2020). Urban artificial lighting systems play an additional role in these environments. The presence of bright building lighting interferes with birds' regular roosting behaviour, causing them to seek rest on lit structures (Sun et al., 2020). According to Kodmany (2018), birds select nesting positions around high-rise buildings based on wind conditions because they prefer areas with reduced airflow.

3.2.3 Food Availability

The availability of a constant food supply in urban areas creates ideal conditions that draw numerous birds (Lowry et al., 2013). High-rise buildings attract more birds because of improper waste management practices and open garbage bins together with intentional feeding activities (Janus & Lesinski, 2018). The availability of food scraps creates ideal conditions for both pigeons and crows which enables them to establish permanent nest sites (Spennemann & Watson, 2018). Buildings with outdoor dining spaces, rooftop cafes, and exposed trash disposal areas unintentionally draw birds seeking food, according to Clark et al. (2020). The regular food supply in these areas motivates birds to settle near human areas which leads to increased droppings throughout the area (Balasubramaniam et al., 2021).

3.2.4 Human Activities

Human actions through behaviour create specific patterns for bird nesting activity within high-rise buildings. The process of construction enables birds to build their nests because scaffolding and unfinished structures function as suitable nesting locations (Spennemann & Watson, 2018). Bird populations settle into existing areas which they initially occupied after construction ends (Clark et al., 2020). The practice of public bird feeding helps birds establish themselves in urban environments. Bird populations within urban areas grow because both pigeons and crows find an abundance of food at human feeding locations (Balasubramaniam et al., 2021). Green spaces, rooftop gardens, and courtyards found in buildings provide birds with both food resources and materials for building nests which boosts their chances of settlement (Sun et al., 2020). Birds select locations with minimal human activity for nesting which includes mechanical rooms together with underutilized balconies and rooftop installations since these spaces create minimal disturbance (Kodmany, 2018).

3.2.5 Predation and Safety

The absence of natural predators in high-rise environments constitutes one major factor that allows birds to succeed. The natural landscape of birds exposes them to hawks, snakes and other predators yet urban areas create a more secure space for nesting (Spennemann & Watson, 2018). Bird populations grow without restraint because predation is absent which results in higher nesting densities (Clark et al., 2020). Group roosting behaviour that pigeons exhibit helps them survive better

through decreased exposure to dangers (Balasubramaniam et al., 2021). The grouping behaviour leads to excessive accumulation of droppings at locations which create extensive maintenance difficulties for high-rise buildings (Kodmany, 2018).

3.3 ISSUES ARISING DUE TO BIRD NESTING AND DROPPINGS IN HIGH-RISE BUILDINGS

The nesting behaviour of birds thrives within urban high-rise buildings, which creates multiple structural, health and safety problems, financial expenses, and visual disturbances. Droppings and nesting materials that accumulate create problems for building structures and represent health risks for residents as well as maintenance workers and facility managers (Gelder, 2003). Bird activities within high-rise buildings present multiple complex problems that need a thorough evaluation to determine their effects on the future maintenance of buildings and urban infrastructure. Figure 2 displays the main issues that arise due to birds in the buildings.

3.3.1 Issues for Building Elements (Structural Damage)

Bird nesting and droppings inflict substantial harm to high-rise structures by damaging concrete and metal materials as well as glass elements and roofing surfaces. Nesting material creates blockages that interrupt drainage systems and ventilation pathways, causing operational problems that cost money to fix. Uric acid in bird droppings, together with the physical accumulation of nests and debris in important building locations causes these structural problems (Spennemann & Watson, 2018).

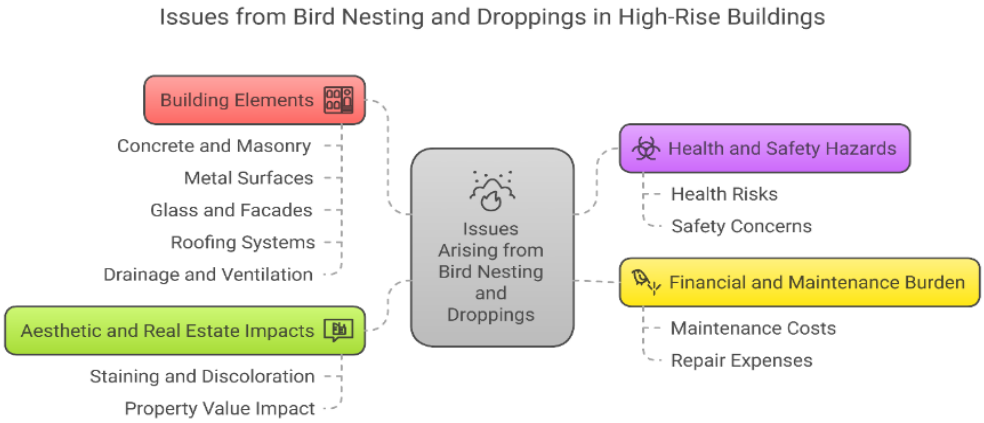


Figure 2: Major issues arise due to birds

3.3.2 Impact on Concrete and Masonry (Corrosion and Cracking Due to Uric Acid)

Bird droppings inflict significant damage on concrete and masonry surfaces because these materials have a porous composition. The uric acid in bird droppings maintains a pH level between 3 and 4 to create conditions that degrade concrete by breaking down calcium carbonate in the material (Clark et al., 2020). Prolonged exposure to bird droppings results in a degradation of concrete material strength,

which creates erosion of surfaces and deep cracks that let moisture reach the inner layers.

The entrance of moisture leads to concrete degradation that expands the material and creates fractures, which ultimately results in spalling (Sun et al., 2020). The rate of deterioration reaches its highest point in coastal cities because the combination of high humidity worsens the chemical interaction between building materials (Forr et al., 2022). Studies reveal that when bird droppings remain uncleaned, they decrease concrete durability by 40%, which requires increased maintenance work and resurfacing (Kodmany, 2018).

3.3.3 Impact on Metal Surfaces (Rusting and Degradation of Window Frames, Railings)

Metal surfaces face severe threats from bird droppings because their acidic nature speeds up oxidation processes and corrosion effects. The chemical interactions between uric acid and aluminium steel and iron components used in windows, beams, and balcony railings result in material degradation and rust formation (Spennemann & Watson, 2018). The duration that droppings stay on metal surfaces, along with moisture exposure from rain and humidity, intensifies this problem. The chemical reaction produces deep holes in the metal structure known as pitting corrosion, which severely weakens material durability (Forr et al., 2022). Unprotected metal surfaces develop corrosion at a rate five times faster than normal when exposed to bird droppings, according to Janus and Lesinski (2018). High maintenance expenses for cleaning operations exist due to the need for frequent cleaning to prevent long-term damage from corrosion on high-rise buildings. Facility managers must replace corroded metal fixtures because the damage exceeds repairability, which leads to additional expenses (Clark et al., 2020).

3.3.4 Impact on Glass and Facades (Staining and Discoloration)

Modern high-rise buildings commonly use glass facades, which experience high susceptibility to permanent staining and etching caused by bird droppings. Glass rejects the absorption of uric acid, yet extended contact leads to permanent discoloration through surface etching which results in glass becoming hazy and permanently clouded (Sun et al., 2020). Building exteriors that use glass facades face significant aesthetic damage, which harms the property value and market appeal of commercial and luxury residential properties. The accumulation of droppings on windows creates visibility reduction through blocked natural light, which requires regular professional cleaning services (Kodmany, 2018). According to Spennemann & Watson (2018), urban high-rises with glass exteriors need regular maintenance cycles of 2-3 weeks when bird droppings affect their surfaces, thus escalating building maintenance costs. Acidic etching creates surface weaknesses in glass, which will eventually lead to cracking (Clark et al.,2020).

3.3.5. Impact on Roofing Systems (Erosion and Leakage Caused by Acidic Runoff)

Bird droppings have a severe impact on roofing systems because they are exposed to environmental conditions. Uric acid in droppings creates acidic runoff after combining with rainwater, which progressively destroys roofing materials, including asphalt shingles, tiles, and membranes (Balasubramaniam et al., 2021). Flat roofs

covered in stagnant water provide perfect conditions where droppings can gather to speed up material breakdown processes (Clark et al., 2020). The acidic material that flows from roofing surfaces weakens the structure until water enters through leaks and mould forms inside (Clark & Shah, 2019). Building owners must replace roofs prematurely because the maintenance costs rise together with reduced lifespan, which stems from severe building damage (Sun et al., 2020). When birds occupy rooftops, they create drainage system blockages that block water runoff, which leads to structural damage through water accumulation (Kodmany, 2018).

3.3.5 Blockage of Drainage and Ventilation Systems (Obstruction by Nests and Droppings)

The presence of bird nests and their droppings accumulation creates blockages which disrupt fundamental building systems such as drainage systems and ventilation and air conditioning units. The placement of nesting materials across rooftop gutters along with downspouts causes rainwater accumulation that produces leaks and leads to interior flooding (Spennemann & Watson, 2018).

HVAC systems and exhaust fans along with chimneys face vulnerability from bird nesting which produces airflow limitations and overheating effects and leads to mechanical breakdowns (Janus & Lesinski, 2018). When ventilation is blocked it produces inferior indoor air quality while increasing power costs and raising fire risks because components become overheated (Clark & Shah, 2019). The study by Sun et al. (2020) identified that intake vents experienced clogging due to bird nesting materials in 60% of HVAC malfunctions that occurred in buildings prone to bird activity. System functionality requires regular inspection followed by nest removal to stop permanent damage from occurring.

3.3.6 Health and Safety Issues

The presence of bird droppings represents a significant health risk to communities because these droppings contain dangerous pathogens and zoonotic diseases. Studies have found more than sixty diseases that can be transmitted through bird droppings with histoplasmosis, cryptococcosis, and psittacosis among them (Stafford III, 2004). People who contact with infected surfaces face serious health risks alongside residents and personnel who maintain the building and those who visit the facility. The most significant health risk takes place because dried bird droppings spread spores through the air. The disturbance of these spores releases them into the air, leading to respiratory illnesses like others have reported (Balasubramaniam et al., 2021). Buildings that have ventilation systems infected with bird excrement face high risks because airborne spores spread to indoor zones where occupants become exposed to health dangers (Spennemann & Watson, 2018). The presence of bird droppings on walkways, staircases, and balconies poses both health hazards and dangerous slip risks that raise injury probabilities (Schmidt et al., 2005). Research shows that urban environments experience a substantial number of slip-and-fall accidents because of bird droppings (Clark et al., 2020).

Facility managers operating in high-rise buildings face legal risks from fall accidents triggered by slippery surfaces, thus making bird management issues more difficult. The presence of bird nests in electrical and mechanical installations creates significant fire risks. Birds construct their nests within air conditioning units,

electrical boxes, and ventilation ducts, which enable overheated nesting materials to ignite into electrical fires (Sun et al., 2020). Urgent bird management solutions must be developed for high-rise buildings because of these recently reported incidents.

3.3.7 Financial and Maintenance Impact

Bird nesting, along with their droppings, creates significant financial burdens by increasing maintenance expenses and reducing building market value. Specialized procedures, including high-pressure washing, chemical treatments, and manual scrubbing, become necessary to remove bird droppings and nests (Janus & Lesinski, 2018). The occurrence of cleaning cycles is more frequent in buildings with substantial bird populations, which drives up operational expenses together with labour costs (Clark et al., 2020).

According to research on urban property management, buildings that experience bird droppings require exterior maintenance costs that increase by as much as 30% compared to unaffected properties (Spennemann & Watson, 2018). The additional expense required for cleaning combined with repainting and material substitution, creates substantial financial challenges for property owners and management companies. Bird-caused property damage forces property owners to pay elevated insurance premiums on top of their cleaning expenses. Structural repairs on buildings with bird-related damage earn insurance agencies a higher classification as risky properties, which drives policy rates for such repairs higher (Sun et al., 2020). Bird-related expenses create sustained economic problems for buildings that lack proper bird management methods in high-rise structures.

3.3.8 Aesthetic and Real Estate Impact

High-rise buildings depend heavily on their visual appearance to determine both their property value and their market potential. Bird droppings cause permanent stains on facades as well as balconies and windows, which diminishes building reputation and leads to tenant dissatisfaction (Kodmany, 2018). The visual appearance of commercial properties and luxury residential buildings depends on exterior cleanliness because it determines market desirability for buyers and tenants (Clark et al., 2020).

The appearance of buildings deteriorates when aesthetics degrade, which leads to decreased property values. Bird-related damage that can be observed by potential renters or buyers frequently leads to reduced property demand and income reductions through negative perceptions about building maintenance quality (Spennemann & Watson, 2018). The unpleasant odour from accumulated birds due to droppings causes discomfort among building occupants and forms negative impressions about building cleanliness (Balasubramaniam et al., 2021). The maintenance of high-rise building aesthetics, together with commercial value, requires immediate proactive bird control strategies.

3.4 STRATEGIES TO MITIGATE AND ELIMINATE BIRD-RELATED ISSUES

Multiple strategies, including physical barriers together with chemical substances and bio-acoustic devices, as well as habitat adjustments and technological developments, aim to reduce bird impacts in high-rise buildings. Figure 3 depicts several strategies that are used to mitigate and eliminate bird-related issues. The

implementation of these strategies produces different levels of effectiveness alongside variable sustainability and cost characteristics, thus demanding specific urban solutions.

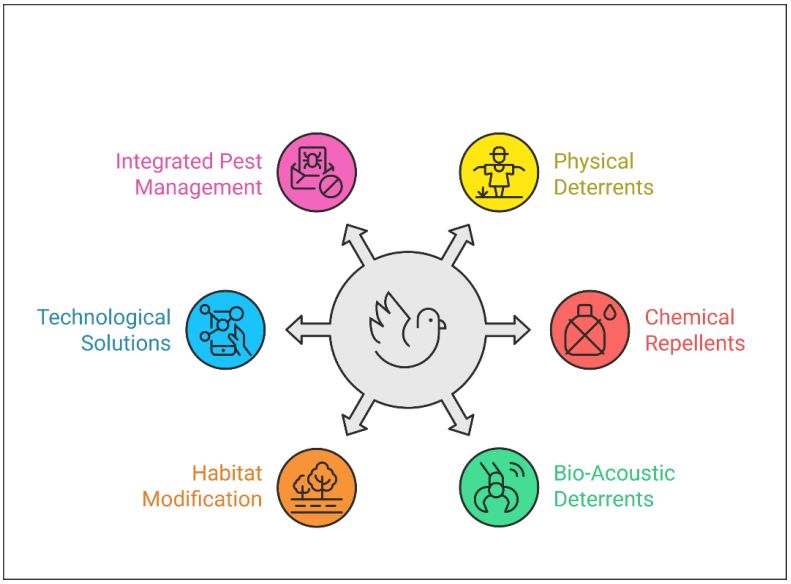


Figure 3: Bird controlling strategies

3.4.1 Physical Deterrents

The implementation of bird spikes and netting stands as the primary barrier approach for stopping birds from using building ledges and balconies as roosting sites (Clarke, 2004). Also, large open areas receive effective protection from netting, and bird spikes effectively stop birds from accessing narrow ledges (Williams et al., 2015). The effectiveness of these solutions decreases when installation goes wrong or when they experience prolonged exposure to weather elements (Dwyer & Mannan, 2007).

3.4.2 Chemical Repellents

Building surfaces receive regular applications of gel-based and scent-based deterrents, which make them unattractive for perching activities (Bishop et al., 2003). Methyl Anthranilate functions as a widely used chemical repellent because its grape-scented composition creates an unpleasant experience for birds through both taste and smell (Clark & Shah, 2019). Rain and environmental exposure diminish chemical repellents, so they need regular reapplication, thus increasing the long-term maintenance expenses (Clark et al., 2020).

3.4.2 Bio-Acoustic Deterrents

Bio-acoustic systems transmit prerecorded predator alarm sounds and distress signals that function as bird deterrents for buildings (Bishop et al., 2003). The technology allows users to program the systems for different types of birds (Seamans et al., 2013). The effectiveness of these devices becomes limited in the long run since birds develop a tolerance to repeated sounds, which demands periodic changes in frequency patterns for continued deterrence (Clarke, 2004).

3.4.4 Habitat Modification

The field of urban planning, together with architecture, has started to redesign buildings in ways that eliminate potential nesting sites (United States Department of Agriculture [USDA] & Tennessee Valley Authority [TVA], 2014). The combination of sloped surfaces with smooth building exteriors and the removal of small ledges stops birds from establishing their nests (Janus & Lesiński, 2018). Secure waste management systems combined with food waste reduction practices eliminate food sources in urban spaces, which make urban buildings less attractive to birds (De Araujo et al., 2018).

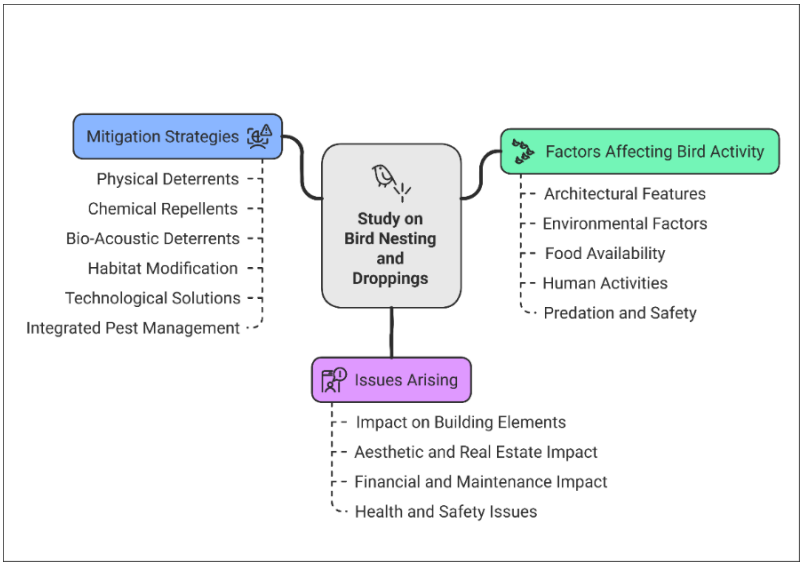
3.4.5 Technological Solutions

The combination of laser-based bird deterrents with automated monitoring systems and AI-driven control methods offers effective non-invasive solutions for addressing bird-related issues (Blackwell et al., 2002). The movement of laser-detected light beams functions as a threat signal for birds, which drives them to stay away from treated areas (Taylor et al., 2018). Automated bird monitoring tools combine motion detectors with video surveillance to sense bird movements, which trigger appropriate deterrent responses (Bishop et al., 2003). AI-based solutions have been developed to study bird behaviour patterns through analysis, which enables dynamic adjustments to deterrent strategies for improved bird control (Balasubramaniam et al., 2021).

3.4.6 Integrated Pest Management (IPM)

The integrated pest management approach develops extensive bird control plans through a combination of physical barriers and chemical and behavioural intervention methods (Clark et al., 2020). The method operates for sustainable long-term outcomes through modifications of bird control strategies, which depend on environmental conditions and bird activities (Baldwin et al., 2017).

Hence, the review of literature could provided valuable insights into the bird nesting and droppings, with a focus on three key areas of concern, and the findings are summarized in Figure 4



.

Figure 4: Summary of literature findings on bird nesting and droppings in high-rise buildings

4. Conclusion

The issues caused by bird nesting and droppings in high-rise buildings emphasise the urgent need for effective strategies to ensure the sustainability of built environments of high-rise buildings (Klug et al., 2023). Figure 4 provides a summary of the main literature findings on bird nesting and droppings in high-rise buildings and creates a compilation of other research. This research demonstrates how bird nesting, combined with their droppings creates significant challenges for high-rise buildings in urban areas. Accordingly, as the study reveals, the bird population at high-rise building structures are increasing because buildings provide suitable habitats and plenty of food sources and lack predator presence. Furthermore, uncontrolled bird activity produces structural harm, financial loss and health dangers as its major effects. The acidic nature of bird excrement speeds up building material breakdown along with concrete, metal and glass surfaces and blocked drainage pipes and ventilation systems creating water damage and HVAC malfunction. The presence of bird droppings creates multiple serious health threats which endanger the health of those living in high-rise buildings along with their maintenance workers. Additionally, the identified controlling strategies imply that the physical barriers combined with chemical repellents and bio-acoustic deterrents fail to establish enduring sustainable solutions for bird control . Thus, the integration of bird management strategies with emerging technological approaches would improve the productivity of the solutions (Harris et al., 2018). Policymakers should design appropriate regulations and building codes on bird management at the design stage. The practitioners of the industry should also embrace the use of integrated bird deterrent systems that incorporate physical, chemical, and smart technologies. The academics are encouraged to further study bio-acoustic adaptation, material innovations and AI-powered surveillance.

Beyond the identified control measures, this research underscores the requirement of a robust framework to effectively and efficiently address this issue. Hence, future studies can develop upon this research to develop such a framework. The outcome of this work will be immensely advantageous to facilities/maintenance managers, helping ensure the well-being of the building structure, reducing maintenance costs, and improving stakeholder satisfaction and safety within tall buildings.

5. References

Al-Kodmany, K. (2018). Sustainability and the 21st-century vertical city: A review of design approaches of tall buildings. In Buildings (Vol. 8, Issue 8). MDPI AG. https://doi.org/10.3390/buildings8080102

Balasubramaniam, K. N., Bliss-Moreau, E., Beisner, B. A., Marty, P. R., Kaburu, S. S. K., & McCowan, B. (2021). Addressing the challenges of research on human-wildlife interactions using the concept of Coupled Natural & Human Systems. In Biological Conservation (Vol. 257). Elsevier Ltd. https://doi.org/10.1016/j.biocon.2021.109095

Baldwin, R., Wilcox, S., & Barnett, J. (2017). Integrated pest management strategies for urban bird control. Pest Management Science, 73(2), 245–253. https://doi.org/10.1002/ps.4532

Bishop, J., Mckay, H., Parrott, D., & Allan, J. (2003). Review of international research literature regarding the effectiveness of auditory bird scaring techniques and potential alternatives.

Blackwell, B. F., Bernhardt, G. E., & Dolbeer, R. A. (2002). Lasers as nonlethal avian repellents. Journal of Wildlife Management, 66(1), 250. https://doi.org/10.2307/3802891

Clark, D. E., & Shah, R. (2019). Evaluating the effectiveness of chemical repellents for urban bird management. Environmental Management, 53(4), 667–674. https://doi.org/10.1007/s00267-019-1212-4

Clark, L., Eisemann, J., Godwin, J., Horak, K. E., Oh, K., O'Hare, J., Piaggio, A., Pepin, K., & Ruell, E. (2020). Invasive Species Control and Resolution of Wildlife Damage Conflicts: A Framework for Chemical and Genetically Based Management Methods (pp. 193–222). https://doi.org/10.1007/978-3-030-53183-6_9

Clarke, T. L. (2004). An autonomous bird deterrent system. ResearchGate. https://www.researchgate.net/publication/279478907_An_autonomous_bird_deterrent_system

De Araujo, G. M., Peres, C. A., Baccaro, F. B., & Guerta, R. S. (2018). Urban waste disposal explains the distribution of Black Vultures (Coragyps atratus) in an Amazonian metropolis: management implications for birdstrikes and urban planning. PeerJ, 6, e5491. https://doi.org/10.7717/peerj.5491Dwyer, J. F., & William Mannan, R. (2007). PREVENTING RAPTOR ELECTROCUTIONS IN AN URBAN ENVIRONMENT. Journal of Raptor Research, 41(4), 259–267. doi:10.3356/0892-

Fitzwater, W. D. (1988). SOLUTIONS TO URBAN BIRD PROBLEMS. https://www.semanticscholar.org/paper/SOLUTIONS-TO-URBAN-BIRD-PROBLEMS-Fitzwater/71e36762eecb7463b79216611b57d5a036fee235#related-papers

Forr, F., Mysliu, E., Nordlien, J. H., & Erbe, A. (2022). The effect of bird droppings on the corrosion of steel and aluminum used in offshore applications. Materials and Corrosion, 74(3), 464–481. https://doi.org/10.1002/maco.202213533

Gelder, J. (2003). BIRDS AND BUILDINGS. Source: Environment Design Guide, 56, 1–10. https://doi.org/10.2307/26148829

Harris, E., De Crom, E. P., Fouche, J., & Wilson, A. (2018). Comparative study on the short-term effects of audio and visual raptor presence on a pigeon population, with a view towards pest control. International Journal of Pest Management, 66(1), 31–39. https://doi.org/10.1080/09670874.2018.1542185

Janus, K., & Lesinski, G. (2018). Birds and bats using buildings as a place of breeding or shelter. Annals of Warsaw University of Life Sciences - SGGW - Animal Science, 57(1), 19–29. https://doi.org/10.22630/aas.2018.57.1.2

W, P. G., Terrell, P. S., & Crabb, A. . C. (2000). A national review of the status of trapping for bird control. Proceedings - Vertebrate Pest Conference, 19. https://doi.org/10.5070/v419110061

Klug, P. E., Shiels, A. B., Kluever, B. M., Anderson, C. J., Hess, S. C., Ruell, E. W., Bukoski, W. P., & Siers, S. R. (2023). A review of nonlethal and lethal control tools for managing the damage of invasive birds to human assets and economic activities. In Management of Biological Invasions (Vol. 14, Issue 1, pp. 1–44). Regional Euro-Asian Biological Invasions Centre. https://doi.org/10.3391/mbi.2023.14.1.01

Lowry, H., Lill, A., & Wong, B. B. M. (2013). Behavioural responses of wildlife to urban environments. Biological Reviews, 88(3), 537–549. https://doi.org/10.1111/brv.12012

Schmidt, R. H., Erickson, D. J., Wainness, H., & Paul, S. (2005). Sanitary Design and Construction of Food Processing and Handling Facilities 1. http://edis.ifas.ufl.edu

Seamans, T. W., Martin, J. A., & Belant, J. L. (2013). Tactile and Auditory Repellents to Reduce Wildlife Hazards to Aircraft. https://digitalcommons.unl.edu/icwdm_usdanwrc

Spennemann, D. H. R., & Watson, M. J. (2018). Experimental Studies on the Impact of Bird Excreta on Architectural Metals. Source: APT Bulletin: The Journal of Preservation Technology, 49(1), 19–28. https://doi.org/10.2307/26452201

Stafford III, K. C. (2004). Tick Management Handbook A integrated guide for homeowners, pest control operators, and public health officials for the prevention of tick-associated disease The Centers for Disease Control and Prevention The Connecticut Agricultural Experiment Station. www.semguy.com

Sun, L., Chen, J., Li, Q., & Huang, D. (2020). Dramatic uneven urbanization of large cities throughout the world in recent decades. Nature Communications, 11(1). https://doi.org/10.1038/s41467-020-19158-1

Taylor, J., Harrison, K., & Green, P. (2018). Laser technology for humane bird deterrence in urban environments. Journal of Wildlife Management, 82(6), 1234–1242. https://doi.org/10.1111/jwmg.12412

Torelli, R., Balluchi, F., & Furlotti, K. (2020). The materiality assessment and stakeholder engagement: A content analysis of sustainability reports. Corporate Social Responsibility and Environmental Management, 27(2), 470–484. https://doi.org/10.1002/CSR.1813

United States Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services, in cooperation with Tennessee Valley Authority. (2014). Environmental assessment: Managing damage caused by birds in the state of Tennessee. https://www.aphis.usda.gov/wildlife_damage

Williams, G. M., Whittaker, R. H., & Nelson, L. (2015). Perching prevention techniques in urban architecture. Urban Ecology Reports, 24(2), 77–83. https://urbanecologyjournals.com/prevention-techniques